

Teacher Guide: Mouse Genetics (Two Traits)



Learning Objectives

Students will...

- Explore inheritance of two traits.
- Use Punnett squares to model the inheritance of two traits and predict probabilities of each offspring's allele combination.
 - Use two Punnett squares to model each trait independently, then multiply the probabilities to find the probability of a given allele combination.
 - Use a single 4x4 Punnett square to model the inheritance of two traits.



Vocabulary

allele, genotype, phenotype, probability, Punnett square

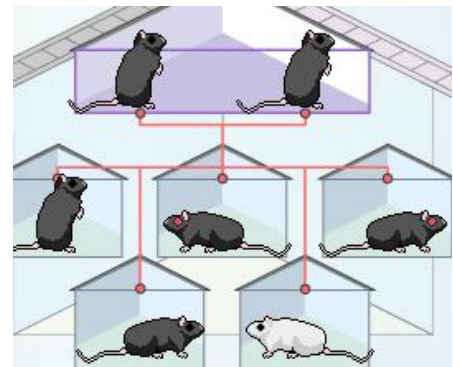


Lesson Overview

In the *Mouse Genetics (One Trait)* Gizmo™, students learned to use Punnett squares to model the inheritance of a single trait, fur color. The *Mouse Genetics (Two Traits)* Gizmo shows the inheritance of fur color *and* eye color.

The Student Exploration sheet contains three activities:

- Activity A – Students breed mice and find patterns in the offspring phenotypes.
- Activity B – Students use two Punnett squares to model the inheritance of two independent traits.
- Activity C – Students use a 4x4 Punnett square to model the inheritance of two traits.



Proud mouse parents and offspring



Suggested Lesson Sequence

1. Pre-Gizmo activity

(🕒 45 – 60 minutes)

Do the *Mouse Genetics (One Trait)* Gizmo and Student Exploration sheet with your students. At the end of this activity, students should be comfortable using Punnett squares to model parent and offspring allele combinations. Students should be able to predict the percentages of offspring genotypes and phenotypes. These skills will be used to complete the *Mouse Genetics (Two Traits)* Gizmo activities.

To prepare for two traits, discuss how to calculate the probability of a combination of events. For example, what is the probability of flipping a coin and getting two heads in a row? To determine this probability, have students list all of the possible outcomes of flipping a coin twice. (There are four equally probably possible combinations: *HH*, *HT*, *TH*, and *TT*.) One of these four is two heads, so there is a one in four (25%) probability of flipping two heads. This is also equal to the probability of getting a head on the first flip (0.5) multiplied by the probability of getting a head on the second flip (0.5). Gather coin-flipping data to confirm that actual results are relatively close to those predicted by probability.

2. **Prior to using the Gizmo** (🧠 10 – 15 minutes)

Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations. Demonstrate how to take a screenshot and paste the image into a blank document.

3. **Gizmo activities** (🧠 15 – 20 minutes per activity)

Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (🧠 15 – 30 minutes)

As students are working or just after they are done, discuss the following questions:

- What is the genotype of a mouse with white fur and red eyes?
- What are the possible genotypes of a mouse with black fur and black eyes?
- Without looking at its genotype directly, how could you determine the genotype of a mouse with black fur and black eyes?
- Two $Ff Ee$ mice are bred. What is the probability of an offspring with white fur and red eyes? [The odds are 1 in 16, or a 6.25% probability.]
- An $ff Ee$ mouse is bred to an $Ff Ee$ mouse. Determine the following probabilities:
 - Black fur, black eyes. [3/8, 37.5%]
 - Black fur, red eyes. [1/8, 12.5%]
 - White fur, black eyes. [3/8, 37.5%]
 - White fur, red eyes. [1/8, 12.5%]

5. **Follow-up activity** (🧠 30 – 45 minutes)

In the *Mouse Genetics (One Trait)* Teacher Guide, the suggested follow-up activity is an experiment in which students pick alleles out of paper bags. A similar activity can be done after using the *Mouse Genetics (Two Traits)* Gizmo. Each student will need two paper bags and four “alleles.” You can use any material for the alleles: paper, marbles, blocks, coins, etc. Assign each student a genotype for fur color (FF , Ff , or ff) and eye color (EE , Ee , or ee) and ask them to label their alleles appropriately.

To model reproduction, have the students work in pairs. Each student closes his or her eyes and draws an allele from each bag. The four total alleles give the offspring genotype, and then the alleles are returned to the bags. Repeat this experiment nine times and record the results. Ask students to switch partners (or alleles) several times so that they can see a variety of results.

When all of the data have been collected, tally the results for each combination of parents on the board. How close were these results to the ratios predicted by Mendel's Laws? (Note: You will probably have to record large numbers of trials for each parent combination to see results that come close to those predicted by probability.)



Scientific Background

Two understand the inheritance of two traits, it is important to learn some basic probability. If two events are independent, the probability of both events occurring is equal to the probability of the first event multiplied by the probability of the second. For example, assume that the probability of wearing a white shirt and the probability of having spaghetti for dinner are independent. If there is a 20% chance of wearing a white shirt and a 30% chance of eating spaghetti, the probability of *both* occurring is $0.2 \cdot 0.3 = 0.06$, or 6%. (Of course, a person might want to avoid wearing a white shirt to a spaghetti meal. In that case, the probabilities are not independent.)

The same principle applies to genetics. Consider the case of breeding two *Ff Ee* mice. Based on the Punnett squares, there is a 75% probability of an offspring with black fur (*FF* or *Ff*) and a 25% probability of an offspring with red eyes (*ee*). So the probability of an offspring with black fur and red eyes is $0.75 \cdot 0.25 = 0.1875$, or 18.75% (3/16).

All of the possible offspring genotypes are shown on an expanded Punnett square (right). Each parent donates one of four possible allele combinations to an offspring. This yields 16 possible offspring genotypes.

		Parent 1			
		<i>FE</i>	<i>Fe</i>	<i>fE</i>	<i>fe</i>
Parent 2	<i>FE</i>	<i>FF EE</i>	<i>FF Ee</i>	<i>Ff EE</i>	<i>Ff Ee</i>
	<i>Fe</i>	<i>FF Ee</i>	<i>FF ee</i>	<i>Ff Ee</i>	<i>Ff ee</i>
	<i>fE</i>	<i>Ff EE</i>	<i>Ff Ee</i>	<i>ff EE</i>	<i>ff Ee</i>
	<i>fe</i>	<i>Ff Ee</i>	<i>Ff ee</i>	<i>ff Ee</i>	<i>ff ee</i>

Equivalent genotypes are combined in the probabilities given below:

FF EE: $1/16 = 6.25\%$

FF Ee: $2/16 = 12.5\%$

FF ee: $1/16 = 6.25\%$

Ff EE: $2/16 = 12.5\%$

Ff Ee: $4/16 = 25\%$

Ff ee: $2/16 = 12.5\%$

ff EE: $1/16 = 6.25\%$

ff Ee: $2/16 = 12.5\%$

ff ee: $1/16 = 6.25\%$

Based on the genotype probabilities, calculate the corresponding phenotype probabilities:

Black fur, black eyes (*FF EE*, *FF Ee*, *Ff EE*, *Ff Ee*): $1/16 + 2/16 + 2/16 + 4/16 = 9/16$ (56.25%)

Black fur, red eyes (*FF ee*, *Ff ee*): $1/16 + 2/16 = 3/16$ (18.75%)

Red fur, black eyes (*ff EE*, *ff Ee*): $1/16 + 2/16 = 3/16$ (18.75%)

Red fur, red eyes (*ff ee*): $1/16$ (6.25%)



Selected Web Resources

Punnett square practice: <http://www.athro.com/evo/gen/punexam.html>,

<http://www2.edc.org/weblabs/Punnett/punnettsquares.html>

Inheritance of two traits: <http://kentsimmons.uwinnipeg.ca/cm1504/dihybrid.htm>,

<http://www.tangerinegecko.com/tgpunnett.html>

Probability and genetics: <http://www.facstaff.bucknell.edu/udaapp/090/w3/matthewr.htm>

Related Gizmos:

Mouse Genetics (One Trait): <http://www.explorelearning.com/gizmo/id?449>

Inheritance: <http://www.explorelearning.com/gizmo/id?657>

Chicken Genetics: <http://www.explorelearning.com/gizmo/id?453>

Hardy-Weinberg Equilibrium: <http://www.explorelearning.com/gizmo/id?517>